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Theoretical and experimental study of enzyme kinetics in a microreactor system with surface-immobilized biocatalyst

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ABSTRACT

A mathematical model comprising transport phenomena and enzyme-catalyzed reaction performed on the inner walls of the continuously operated microreactor with surface-immobilized -transaminase was developed. Oriented enzyme immobilization enabling unhindered accessibility of enzyme active sites was obtained by using fusion protein N-SBM-ATA-wt consisting of selected ω-transaminase ATA-wt and the positively charged Z_{basic2} tag, which established ionic interactions with silicon/glass microchannel surface. Enzyme-catalyzed transamination of (*S*)-(-)-α-methylbenzylamine and pyruvate to acetophenone and L-alanine was described by surface kinetics based on a ping-pong bi-bi mechanism. Reaction kinetic parameters were preliminarily defined in a batch system using various initial substrates concentrations and further applied in the surface reaction description. Based on the prevailing kinetic and convection/diffusion phenomena, the developed model could be reduced to the one-dimensional model which enabled immobilized enzyme concentration estimation and showed good agreement with experimental data from the outlet of the microreactor at various flow rates and inlet substrates concentrations. Moreover, the model successfully predicted performance of two consecutively connected microreactors coated with N-SBM-ATA-wt and could be further used to design and optimize efficient and sustainable processes of chiral amine syntheses catalyzed with surface immobilized enzymes.

Keywords: microreactor; enzyme immobilization; surface-enzyme kinetics; transamination; mathematical modeling

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